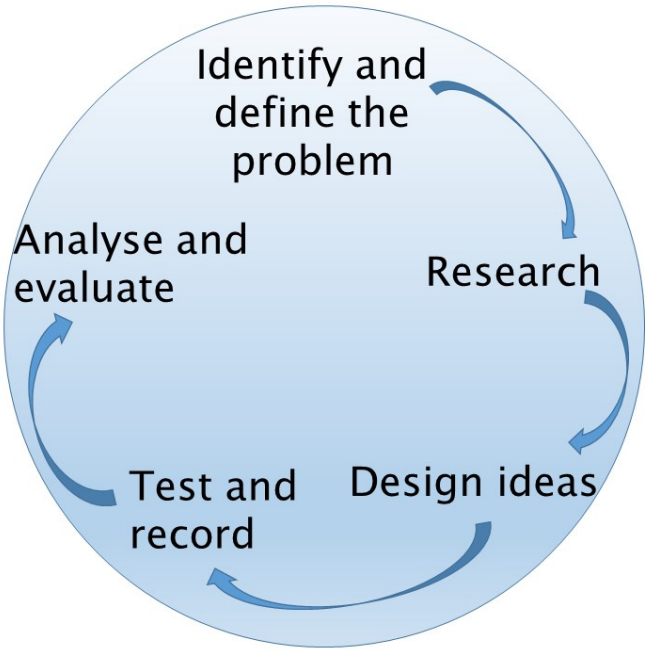
Going for Gold – Student Booklet

The Challenge

Realising that in Western Australia you have a unique opportunity to find a small fortune or at the very least have an adventure, your family decides that their next holiday will be spent fossicking for gold. You know that this could be very hard and also dangerous, so you decide to do some research and investigations in advance to ensure you are well prepared for the undertaking ahead.



Background Information

The discovery of gold in the Kimberley in 1885 sparked the excitement of many, but it was in 1892 when the Gold Rush of Western Australia really started, with the first big discovery at Coolgardie being announced. Further discoveries in Western Australia, including Mount Charlotte, lead to a population boom with over 100,000 people moving to the state in the following 10 years.

In 2015 – 16 gold was the third largest resource exported by Western Australia in regards to value, with a value of $10 billion dollars. This equated to 6.27 million troy ounces. The mine which produced the most in this time period was the Super Pit Gold Mine in Kalgoorlie which produced 700, 000 Troy ounces. However, gold is mined all over the state with mines nearly as far north as Port Hedland, stretching all the way down south to Norseman.

Gold does not usually react with other elements, and so around 70% of it is found as native gold. However, around 20% of it will form compounds with other elements (tellurium, sulphur or selenium) creating minerals known as tellurides. Rocks containing tellurides were initially thought to be fool's gold and were discarded, used as building stone and thrown on walkways (literally paving the streets with gold!) It was only a few years into the

gold rush that the tellurides were discovered to be gold bearing. This is what is mined at the SuperPit at Kalgoorlie now.

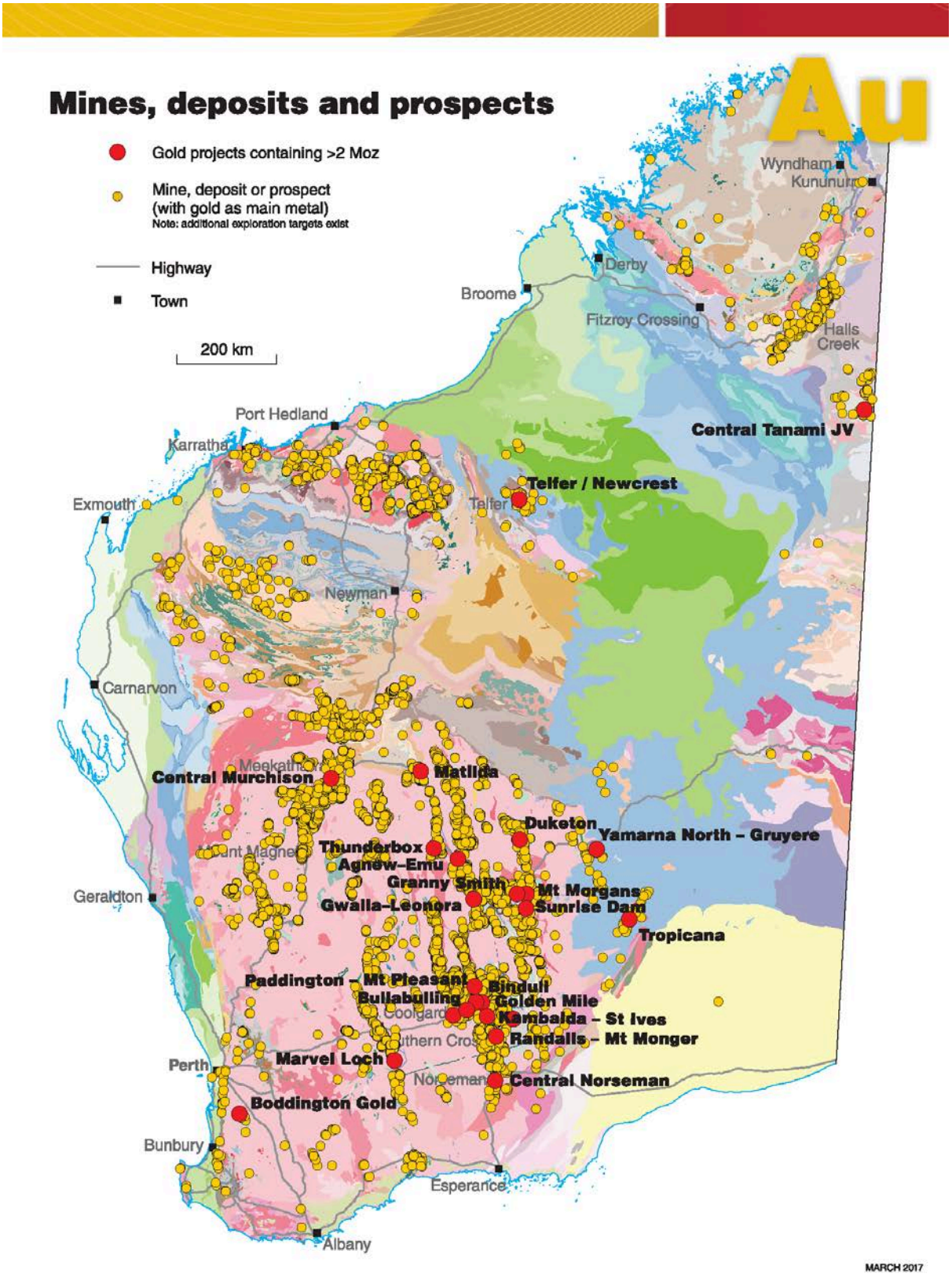


Figure 1. Map of Western Australia, showing some key locations where gold has been found (Geological survey of Western Australia, 2017).

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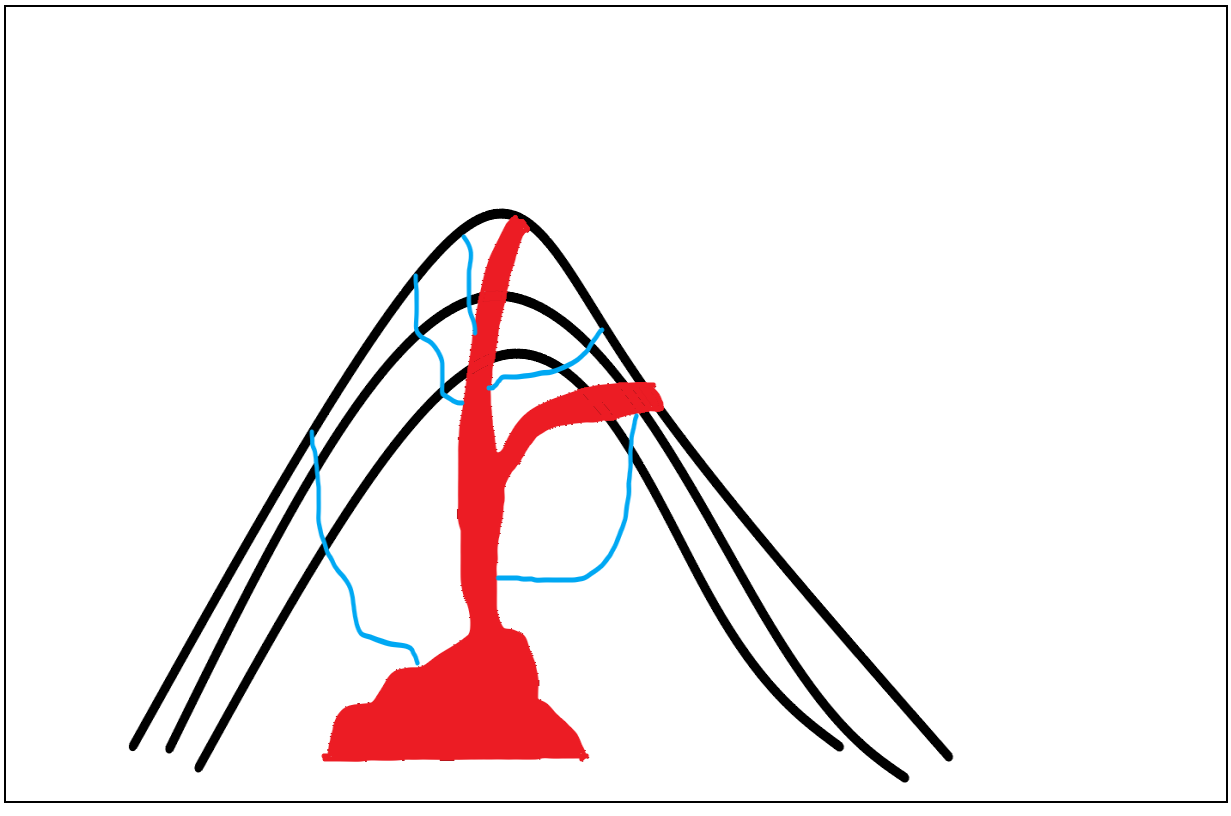
For thousands of years gold has been sought after and used for jewellery and coins all over the globe. However, it has only been in the last hundred years that developments in technology and medicine have led to its other properties being exploited. Nearly all computers and mobile phones will contain small amounts of gold – which is one of the reasons why many phone companies will give you a discount on a new phone if you exchange your old one.

Gold has always been a prized and valuable mineral, even with its market price constantly fluctuating, you can be sure that if you strike gold – you've struck gold!

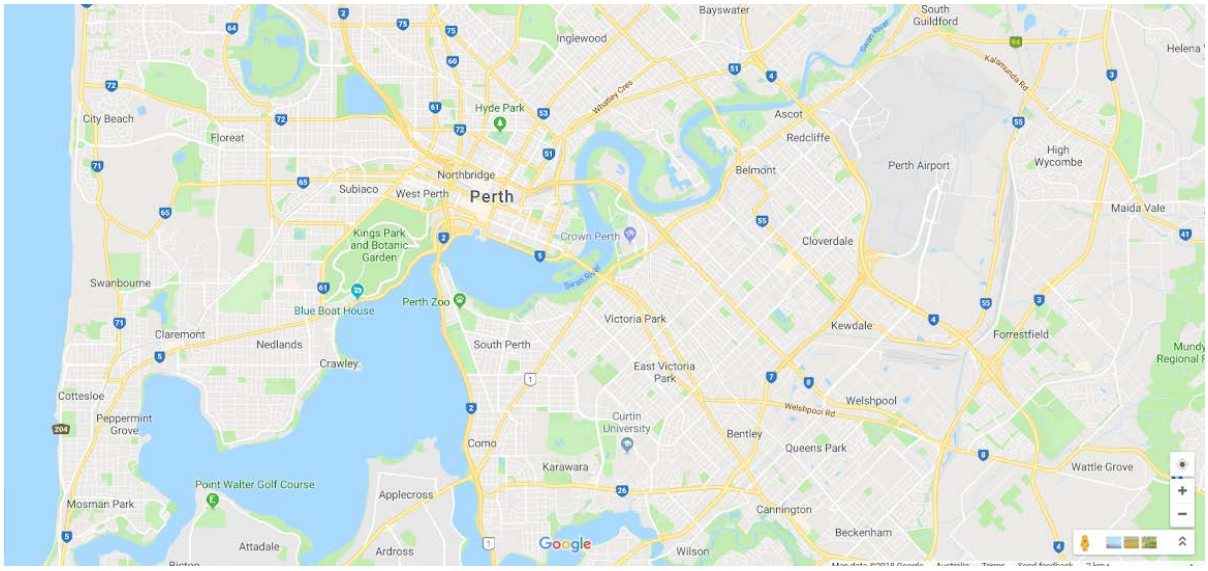
Background Research

1. Add the following labels to the diagram below to help explain one way in which primary (hydrothermal) gold ore deposits are formed:

- magma chamber
- rock layers
- hot, mineral rich fluid
- magma pipes/dykes



2. Primary ore is often weathered and eroded over time and gets transported downstream in rivers. Locations it accumulates are called placer deposits. Shade areas on the picture below to indicate the most likely areas to find gold placer deposits (hint: think about where the water is going slower).



3. Gold deposits are usually called primary or secondary deposits. Explain why they are given these names.

_____

_____

_____

_____

4. Where in Western Australia are the three largest gold mines found?

Mine name	Location

5. Which rock types are the gold mines in Western Australia often associated with?

_____

_____

6. How can gold be separated from surrounding rock?

Separation method	Image / video link	Explanation of how it works.

7. What are some of the properties of gold which could assist you to identify it?

_____

_____

_____

_____

_____

_____

8. Which properties of gold make it useful for jewellery, medicine and electronics?

Property	Definition	Useful for
Malleable		
Ductile		
Good conductor		
Non-reactive		
High boiling point		
Resistance to tarnish		

9. Have there been any recent large finds by fossickers, if so where and how big were the nuggets/finds?

Who found it	Where it was found	How much it was worth	Picture and reference

10. What is the current price of gold?

Price	Reference

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Investigation: How Much is Your Gold Worth?

Although you can always be pretty sure that your gold is going to be valuable, the price of gold is always fluctuating. Therefore if you find gold, or have gold you want to sell, it is always worth analysing the markets to decide if it is a good time to sell, or if you might be better off waiting to see if the market price increases.

1. Find an interactive graph online which shows the price of gold over the past 5 years and paste it here – don't forget to add a reference.

Reference:

2. What was the maximum price of gold over the past 5 years, and when was that?

Maximum price of gold	**Date**

3. What was the minimum price for gold over the past 5 years, and when was that?

Minimum price of gold	**Date**

4. Can you see any patterns in the gold price fluctuation, e.g. seasonal changes, a linear relationship or does it just seem random?

_____

_____

_____

5. What was the price of gold on this day for the past 5 years?

Today	
1 year ago	
2 years ago	
3 years ago	
4 years ago	
5 years ago	

6. Calculate the mean price of gold on this day over the past 5 years. (Show your calculations).

7. Is the price of gold today above or below the mean price on this day over the past 5 years?

The price of gold will depend on its Karat value, and its weight. The purest gold is 24 Karat gold, the lower the number the less pure the gold is. Gold is measured in troy ounces (oz t), there are 31.1 grams in a troy ounce.

8. If 1 oz t = 31.1 g, how many troy ounces are in a kilogram of gold? (Show your calculations).

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How to calculate the price of your gold – EXAMPLE.

Price of gold today (spot price)	$ 1700
Weight of gold	5 grams
Karat	14 k

Step 1. Divide the karat value by 24, and multiply by 100 to find the percentage of pure gold content.
14 / 24 = 0.583
0.583 x 100 = 58.3%
Therefore the percentage of pure gold in 14 k is 58.3%

Step 2. Divide the spot price by 31.1 to determine the price of 1 gram of pure gold (24 karat)
1700 / 31.1 = $54.66

Step 3. Multiply the price per gram of pure gold, by the percentage of gold content as a decimal
$54.66 x 0.583 = $31.87
Therefore the price per gram of 14 K gold is $31.87

Step 4. Multiply the price per gram by the number of grams you have.
$31.87 x 5g = $159.35
So the total value of the gold is $159.35

Find the price of the following, using today's spot price:

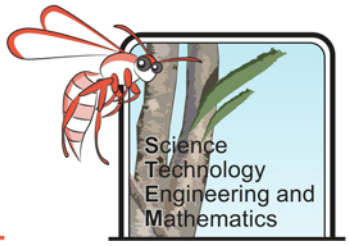
a) 1 g of 24 k gold
b) 10 g of 18 k gold
c) 20 g of 14 k gold

	A	B	C
Step 1			
Step 2			
Step 3			
Step 4			
Price			

Extension

Calculate what the price of samples A, B and C would have been at their highest value on this day and at their lowest values, in the previous 5 years (use your answers from question 5).

Highest price	A	B	C
Step 1			
Step 2			



Step 3			
Step 4			
Price			

Lowest price	A	B	C
Step 1			
Step 2			
Step 3			
Step 4			
Price			

Investigation: Creating a Risk Assessment

Objective

Going fossicking for gold should be an adventure, but it will be tough and could be dangerous. It is very important that you are well prepared and have completed a risk assessment.

Scoring the risk

Before going on a field trip or excursion it is common to use a risk assessment matrix to decide if the activity is too risky to carry out. The likelihood of the risk happening combined with the severity of the outcome if it happens creates the overall risk rating. The risk rating is a score between 1 – 12, with 1 being the lowest risk rating and 12 being the highest.

Risk assessment matrix					
Risk rating key		LOW Acceptable OK to proceed	MEDIUM As low as reasonably practical Take mitigation efforts	HIGH Generally unacceptable Seek support	EXTREME Intolerable Place event on hold
		Severity			
		ACCEPTABLE Little to no effect on event	TOLERABLE Effects are felt, but not critical to outcome	UNDESIRABLE Serious impact to the course of action and outcome	INTOLERABLE Could result in disaster
Likelihood	IMPROBABLE Risk is unlikely to occur	LOW 1	MEDIUM 4	MEDIUM 6	HIGH 10
	POSSIBLE Risk will likely occur	LOW 2	MEDIUM 5	HIGH 8	EXTREME 11
	PROBABLE Risk will occur	MEDIUM 3	HIGH 7	HIGH 9	EXTREME 12

Figure 2. Risk assessment matrix, combining the likelihood of the risk occurring with the severity of the outcome.

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Example - Severity

Acceptable	Tolerable	Undesirable	Intolerable
Minor injury or first aid treatment Example: Insect bite Cutting knee Hit finger with geological hammer	Injury requiring treatment by doctor Example: Getting a small piece of metal stuck in your eye Dropping rock on toe and losing toenail	Major injury requiring time in hospital. Example: Falling in cavern and breaking spine/ bones Severe dehydration	Death of a person or multiple major injuries.

To complete a risk assessment consider what are the main dangers of fossicking in Western Australia. How severe are the risks and what is the likelihood of it happening? Then ensure that you have made it clear how you can avoid the risks occurring. An example has been done for you.

Hazard	What could happen	Severity	Likelihood	Risk rating	How to avoid it
Remote locations with very similar scenery.	Get lost and become severely dehydrated.	Undesirable	Improbable	6 – Medium risk	Always tell people where you are going, take a map and compass and carry a Personal Location Beacon (PLB) or EPIRB.

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Investigation: Rock Identification

Objective

To be able to identify different rock types, in particular those which are commonly linked to where gold is found in Western Australia, and explain how their appearance is linked to their formation.

Equipment

- Array of rock samples (including some from gold mining areas)
- Hand lenses

Method

1. Note how the rocks feel: light/ heavy, smooth/rough, crumbly/consolidated etc. and record in the table.
2. Make visual observations about the rocks e.g. colour, shiny/ dull, crystals/grains (and their size), layers/no layers, contains fossils or not – add these observations to the table provided on the next page.

Results and Analysis

Rock sample number	How does it feel?	Colour (s)	Shiny / dull	Crystals/grains	Layers/ no layers	Contains fossils?

1) Using your observations try to identify your rocks – the WASP app or Rock ID poster should help.

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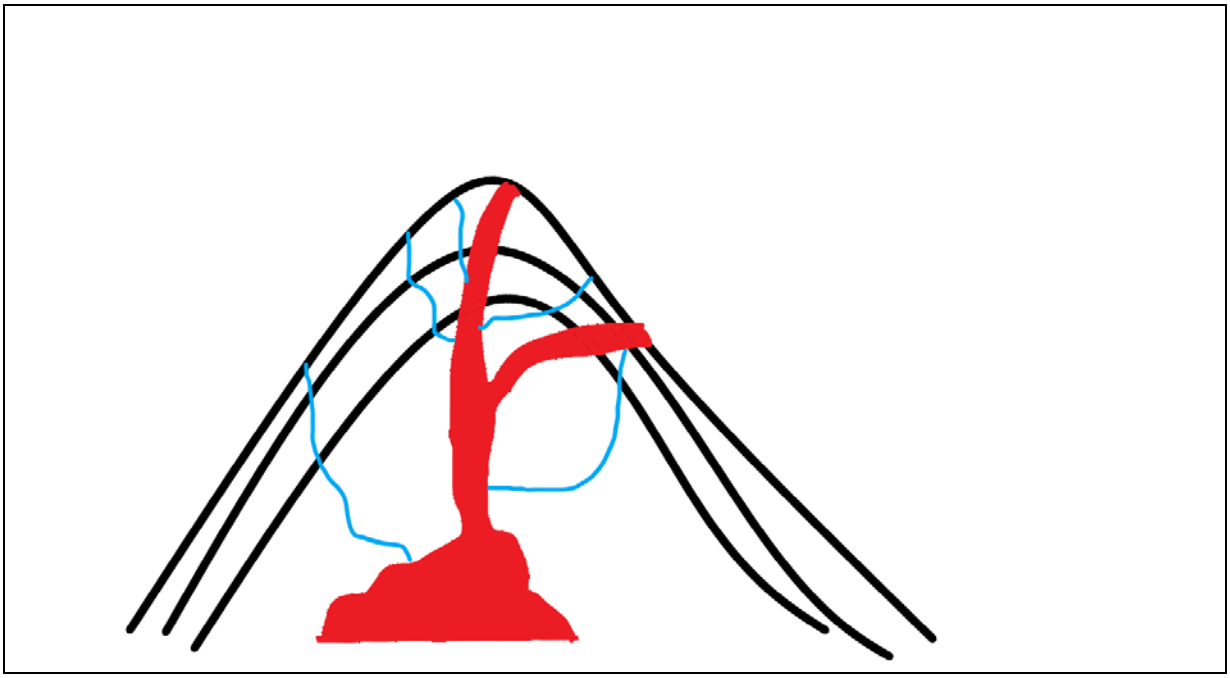
2) Below is a picture showing one way gold can be brought to the surface. Add the following labels to the pictures and circle the rock types/ locations where you would most likely find gold:

- sedimentary rock
- igneous intrusion
- metamorphic rock
- mineral vein



Research

1) Which rock types are the gold mines in Western Australia often associated with?

_____

_____

_____

2) What are the key features of rocks found near gold (e.g. crystals / sediments, colour)?

_____

_____

_____

Evaluation

1) How easy is it to identify the rocks?

_____

2) Why is it equally as important to know what rocks that may contain gold look like as those which are unlikely to contain gold?

_____

_____

3) What equipment would you bring with you on a field trip to help you identify rock types?

_____

_____

_____

4) Choose three very different rocks and draw a labelled diagram to explain how their properties and appearance link to their formation. Where appropriate, include these terms in your explanation: pressure, temperature, crystalise, grains, cool, cement, sediment, time.

Investigation: Determining densities

Figure 3. Archimedes reportedly cried "Eureka! Eureka!" after he stepped into a bath and noticed the water level rising. He realised that the volume of water displaced must be equal to his volume. (Arlindi, 1999)

Objective

To determine the density of different rocks and consider how useful density is as an identification tool when looking for gold bearing rocks in the field.

Useful links: video on how to measure the volume of an irregular shape: https://www.youtube.com/watch?v=e0geXKxeTn4

Equipment

- Range of rock samples
- Weighing scales
- 2 x ice cream tubs
- Beaker
- Tray
- Sand
- Measuring beaker/cylinder (this will depend on size of samples)

Method

1. Use the scales to find the mass of each sample and record it in the table.
2. Fill the ice cream container full of water and place it in the tray.
3. Put a sample into the ice-cream container, so that the water overflows into the tray.
4. Pour the water in the tray into the measuring beaker to determine the volume of water displaced, this is equal to the volume of the rock (1 ml = 1 cm^3) and record in the table.

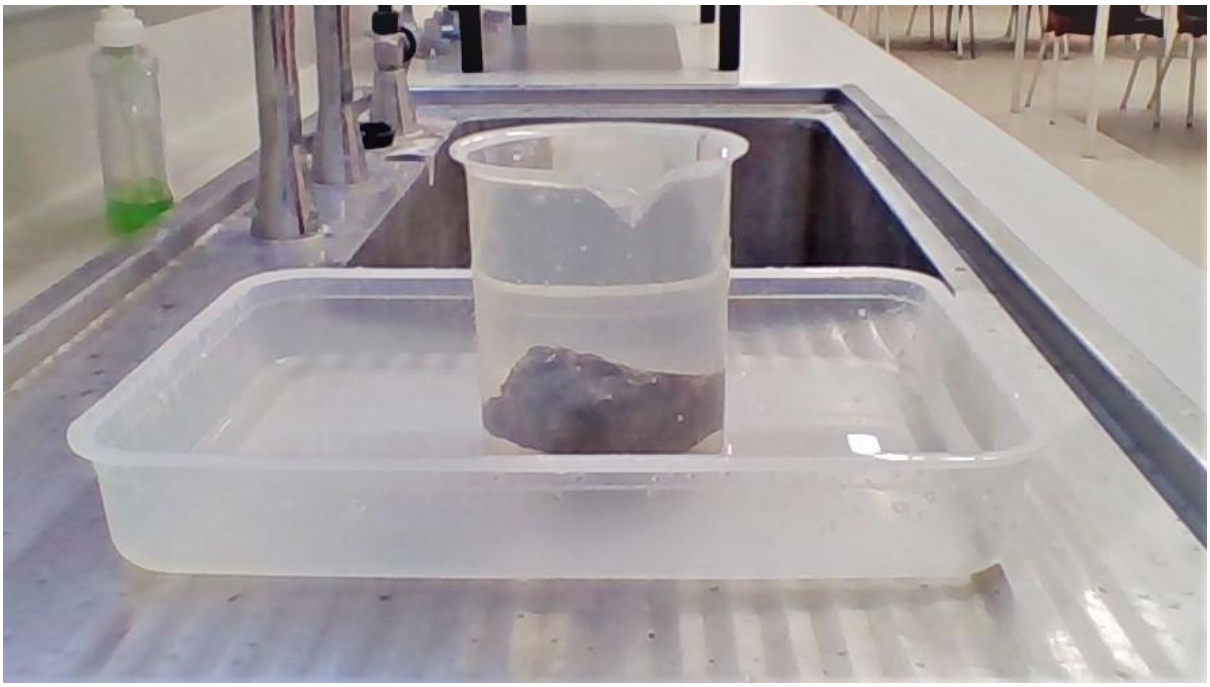


Figure 4. Determining the volume of an irregular shape by placing it in a beaker full of water and then measuring the volume of water with has been displaced into the tray below it.

Note: if you are using small samples, you could just put them in a plastic beaker/ cylinder half filled with water and note how much the water rises when the sample is placed inside, subtracting the difference. Or if you have regular shaped samples you could find the volume mathematically.

Figure 5. If you have a smaller sample you can measure the difference in the level of water before and after a rock is placed into the beaker.

5. *If you have pumice or a sample that will float and hence not displace water:*
   - Fill an ice cream tub to the very top with sand.
   - Put the sample in another identical ice cream tub.
   - Pour the sand over the sample, shaking it gently so the sand works its way into as many interconnected pore spaces as possible, until the container is full and the rock is completely buried.
   - Measure the volume of sand that is left in the first ice-cream container by pouring it into the beaker. The volume of sand in the beaker is equal to the volume of the rock. NB – make sure that everything is kept very dry for this stage otherwise the sand will get stuck to the container and sample.

Results and Analysis

Sample	Mass (g)	Volume (cm^3)	Density (g/cm^3)

1. Calculate the density of the samples by dividing the mass by its volume and add this to the table.
2. List the samples in order from lowest density to highest density.

Lowest							Highest

3. Research densities of the rocks you worked with online and complete the table below.

Rock type	Density (g/cm^3)	Reference

4. Compare your density calculations to densities of rocks found online.

_____

_____

5. In WA primary gold ore is usually found in or near quartz veins. If you are in the field looking for gold, and find a rock outcrop how useful do you think density is as a way of identifying a rock type?

_____

_____

_____

_____

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Investigation: Panning for "gold"

Objective

To be able to separate materials of different density, and understand the principles behind gold panning.

Equipment

- Sand and gravel
- Iron filings or denser small pieces of material to represent gold (of small gold pieces of gold leaf)
- Tray
- Gently curved bowl/ lightweight wok
- Tweezers

Method

1) Pour some sand, gravel and the material representing gold into the tray until it is around 3 cm high and mix very well.
2) Pour some water into the tray so it is covering the mixture by around 3 -5 cm
3) Scoop out some of the mixture and water into your bowl and give it a good swirl – here is a good video on how to pan for gold: https://www.youtube.com/watch?v=ZZMowySFpQc
4) Gently tilt the bowl away from you in the water, and allow the water to wash some of the light sediment away.
5) Pick out any large pieces of gravel you can with your fingers.
6) Repeat steps 3 and 4 until only the very fine sediment is left, gently tilt it and – if you have any "gold" it should become visible.
7) Use your tweezers to take out the "gold" and put it on some paper towel to dry out. Be careful it doesn't blow away.
8) Keep going until you are rich!

Results and Analysis

1. How much did your "gold" weigh?

_____

2. What is the price per gram of gold today?

_____

3. Calculate how much your “gold” is worth by multiplying your weight by the price.

_____

4. How long did you spend fossicking (in minutes)?

_____

5. Convert the length of time into hours, by dividing the number of minutes by 60.

_____

6. Calculate your rate of fossicking by dividing how much your gold is worth by the time taken to find it.

_____

7. Research: what is the minimum wage in Australia?

_____

8. At your current rate of fossicking have you managed to find enough “gold” to pay yourself the minimum wage?

_____

9. At your current rate how long would you have to fossick for to make $1000?

_____

Investigation: Designing a Dry Blower

Objective

Panning for gold using water is not particularly viable in Western Australia, therefore for your adventure to succeed you will need to design a dry blower/washer to bring with you.

Specifications

The dry blower needs to be portable so that you can take it on your adventure with you, so therefore must be able to fit into the boot of your car/back of your trailer.
Remember the aim of the adventure is to make money – so you should keep the cost as low as possible, perhaps you can recycle old, unwanted items.

Method

1. Research what a dry blower is, and how it works.
2. Draw a labelled diagram to show the key components.

3. What is the function of each of the key components?

Component	**Function**
sluice	
riffles	
screen/grizzly	
hopper	
motor	
recovery tray	

4. Brainstorm replacement materials (simple, cheap and/or recycled materials) that could be used to build a dry blower.

Component	Replacement suggestion 1	Replacement suggestion 2	Replacement suggestion 3

5. Draw and label design ideas, comparing the pros and cons of them.

Design	Pros	Cons

Design	Pros	Cons

6. Write a plan for how you will make your chosen design, ensuring you have completed the risk assessment table. Show this to your teacher and make any necessary changes before making the product.
    a. Equipment and tools needed:

_____

_____

_____

_____

    b. Method/ Steps:

_____

_____

_____

_____

_____

_____

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Risk Assessment

Hazard	Risk	Prevention
e.g. cutting equipment to size	**Could cut fingers/hand**	**Use equipment with care and under supervision. Keep focused. Use the right cutting tools.**

Testing the design

Equipment

- Sand and gravel
- Iron filings or other materials to act as “gold” pieces

Method

1) Weigh how much of each material you have and record this in a table under the heading “before”
2) Mix all the “ingredients” together thoroughly.
3) Slowly add them to your dry blower allowing it time to separate the mixture.
4) Once the mixture has been separated weigh how much of each material you have and put in the table under the heading “after”.

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Results and Analysis

1. How much gold did your dry blower manage to pick up?

_____

2. What percentage of the gold added to the mixture did you end up with at the end? Show calculations.

_____

Evaluation

1. How well did your design work? Did you manage to catch lots of "gold" using your design?

_____

2. What were the strengths and weaknesses of the design?

_____

_____

3. What are your suggestions for improvement to the design?

_____

_____

_____